

**U.S. Department of Energy**  
**Washington, D.C.**

**ORDER**

DOE 5480.5

9-23-86

**SUBJECT: SAFETY OF NUCLEAR FACILITIES**

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1. PURPOSE. To establish nuclear facility safety program requirements to assure that:
  - a. Nuclear facilities are sited, designed, constructed, modified, operated, maintained, and decommissioned in accordance with generally uniform standards, guides, and codes which are consistent with those applied to comparable licensed nuclear facilities;
  - b. Radioactive and fissionable materials are produced, processed, stored, transferred, or handled in such a manner that the probability of an accident is acceptably low;
  - c. An environment, safety, and health (ES&H) program is established in accordance with the requirements stipulated in paragraphs 8 through 13 of this Order;
  - d. Environment, safety, and health (ES&H) matters are comprehensively addressed and receive an objective review, with all identifiable risks reduced to acceptably low levels, and management authorization of the operation is documented;
  - e. Consideration is given to all potential criticality hazards associated with fissionable material operations outside nuclear reactors; and
  - f. Government property and essential operations are protected from the effects of potential accidents.
2. CANCELLATION. DOE 5480.1A, ENVIRONMENTAL PROTECTION, SAFETY, AND HEALTH PROTECTION PROGRAM FOR DEPARTMENT OF ENERGY OPERATIONS, Chapter V, "Safety of Nuclear Facilities," of 8-13-81.
3. SCOPE. The provisions of this Order apply to all Departmental Elements and contractors performing work for the Department as provided by law and/or contract and as implemented by the appropriate contracting officer.
4. REFERENCES.
  - a. DOE 1324.2, RECORDS DISPOSITION, of 5-28-80, which contains procedures for retention of records and documents.

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**DISTRIBUTION:**

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**INITIATED BY:**

Assistant Secretary for Environment,  
Safety, and Health

- b. DOE 5000.3, UNUSUAL OCCURRENCE REPORTING SYSTEM, of 11-7-84, which establishes a system for reporting unusual occurrences having programmatic significance.
- c. DOE 5480.1B, ENVIRONMENT, SAFETY, AND HEALTH PROGRAM FOR DEPARTMENT OF ENERGY OPERATIONS, of 9-23-86, which sets forth the responsibilities and requirements for an ES&H program.
- d. DOE 5480.3, SAFETY REQUIREMENTS FOR THE PACKAGING AND TRANSPORTATION OF HAZARDOUS MATERIALS, HAZARDOUS SUBSTANCES, AND HAZARDOUS WASTES, of 7-9-85, which describes the requirements for packaging and transportation of hazardous materials, hazardous substances, and hazardous wastes.
- e. DOE 5480.4, ENVIRONMENTAL PROTECTION, SAFETY, AND HEALTH PROTECTION STANDARDS, of 5-15-84, which specifies the application of mandatory ES&H standards to DOE operations.
- f. DOE 5480.1A, Chapter XI, "Requirements for Radiation Protection," of 8-13-81, which establishes DOE's radiation protection program.
- g. DOE 5481.1B, SAFETY ANALYSIS AND REVIEW SYSTEM, of 9-23-86, which establishes uniform requirements for the preparation and review of safety analyses.
- h. DOE 5482.1B, ENVIRONMENT, SAFETY, AND HEALTH APPRAISAL PROGRAM, of 9-23-86, which presents DOE's policy and requirements for appraisals of programs.
- i. DOE 5484.1, ENVIRONMENTAL PROTECTION, SAFETY, AND HEALTH PROTECTION INFORMATION REPORTING REQUIREMENTS, of 2-24-81, which establishes the requirements and procedures for reporting and investigating matters of environmental protection, safety, and health protection significance to DOE operations.
- j. DOE 5500.2, EMERGENCY PLANNING, PREPAREDNESS, AND RESPONSE FOR OPERATIONS, of 8-13-81, which establishes requirements for the coordination and direction of planning, preparedness, and response to operational emergencies.
- k. DOE 5500.3, REACTOR AND NONREACTOR NUCLEAR FACILITY EMERGENCY PLANNING, PREPAREDNESS AND RESPONSE FOR DEPARTMENT OF ENERGY OPERATIONS, of 8-13-81, which establishes requirements for the development of site specific emergency plans and procedures at nuclear facilities.
- l. DOE 5500.4, PUBLIC AFFAIRS POLICY AND PLANNING REQUIREMENTS FOR EMERGENCIES, of 8-13-81, which establishes requirements for public affairs actions for emergency situations.

- m. DOE 5700.6B, QUALITY ASSURANCE, of 9-23-86, which describes DOE's quality assurance program.
- n. DOE 6430.1, GENERAL DESIGN CRITERIA, of 12-12-83, which contains the criteria for the design and construction of DOE facilities.
- o. American National Standards Institute standard ANSI/ANS-8.1-1983, "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors," which provides guidance for the prevention of criticality accidents in the handling, storing, processing, and transporting of fissionable materials. This document is available through the American Nuclear Society (see DOE 5480.4).
- p. American National Standards Institute standard ANSI/ANS-8.15-1981, "Nuclear Criticality Control of Special Actinide Elements," which provides guidance for the prevention of criticality accidents in the handling, storing, processing, and transporting of special actinide elements. This document is available through the American Nuclear Society (see DOE 5480.4).
- q. Code of Federal Regulations, Title 10, Part 30, "Rules of General Applicability to Licensing of Byproduct Material," which prescribes rules governing domestic licensing of byproduct material.
- r. Code of Federal Regulations, Title 10, Part 40, "Licensing of Source Material," which establishes procedures and criteria for the issuance of licenses to handle source and byproduct material.
- s. Code of Federal Regulations, Title 10, Part 50, "Licensing of Production and Utilization Facilities," which prescribes criteria governing the licensing of production and utilization facilities.
- t. Code of Federal Regulations, Title 10, Part 70, "Special Nuclear Material," which establishes requirements for transportation and for preparation of shipment of licensed material.

5. DEFINITIONS.

- a. Critical Mass is the smallest mass of fissionable material that will support a self-sustaining chain reaction under specified conditions.
- b. Fissionable Materials are nuclides capable of sustaining a neutron induced fission chain reaction (e.g., uranium-233, uranium-235, plutonium-239, plutonium-238, plutonium-241, neptunium-237, americium-241, and curium-244).

- c. Fissionable Materials Handler is an individual officially designated by management to manipulate or handle significant quantities of fissionable materials, or manipulate the controls of equipment used to produce, process, transfer, store, or package significant quantities of such materials.
- d. Nuclear Criticality is a self sustaining chain reaction, i.e. the state in which the effective neutron multiplication constant of a system of fissionable material equals or exceeds unity.
- e. Nuclear Criticality Safety is the prevention or termination of inadvertent nuclear criticality, mitigation of consequences and protection against injury or damage due to an accidental nuclear criticality.
- f. Nuclear Facility is a facility whose operations involve radioactive materials in such form and quantity that a significant nuclear hazard potentially exists to the employees or the general public. Included are facilities that: (1) produce, process, or store radioactive liquid or solid waste, fissionable materials, or tritium; (2) conduct separations operations; (3) conduct irradiated materials inspection, fuel fabrication, decontamination, or recovery operations; or (4) conduct fuel enrichment operations. Incidental use of radioactive materials in a facility operation (e.g., check sources, radioactive sources, and X ray machines) does not necessarily require the facility to be included in this definition. Accelerators and reactors and their operations are not included.
- g. Operational Readiness Review is a structured method for determining that a project, process, or facility is ready to operate and occupy and includes, as a minimum, review of the readiness of the plant and hardware, personnel, and procedures. The review includes a determination of compliance with ES&H Orders.
- h. Operational Safety Requirements are those requirements which define the conditions, safe boundaries, and bases thereof, and management or administrative controls required to assure the safe operation of a nuclear facility.
- i. Operator is an individual designated by management to perform operations or conduct activities with radioactive materials at a nuclear facility.
- j. Risk is a quantitative or qualitative expression of possible loss which riders both the probability that a hazard will cause harm and the consequences of that event.

- k. Safe Mass is that mass of fissionable materials which is subcritical for all conditions to which it could reasonably be expected to be exposed, including processing, handling, storing, and procedural uncertainties.
- l. Safety Analysis is a documented process to systematically identify the hazards of a DOE operation; to describe and analyze the adequacy of the measures taken to eliminate, control, or mitigate identified hazards and to analyze and evaluate potential accidents and their associated risks.
- m. Safety Guides are documents designated or recognized as an acceptable basis for nuclear criticality safety evaluations. These guides may be used as aids by DOE field organizations in establishing acceptable safety practices, and include material developed by DOE contractors, professional societies, industrial organizations, and foreign atomic energy industries. These guides are listed in paragraph 14.
- n. Significant Quantities are masses of fissionable materials greater than a safe mass, as defined in paragraph 5k.
- o. Significant Modification is a change to a nuclear facility that involves an unreviewed safety question, as defined below.
- p. Supervisor is an individual officially designated by management to direct the activities of operators or fissionable materials handlers and to supervise the operation of equipment that handles, produces, processes, stores, packages, or uses radioactive material or significant quantities of fissionable materials.
- q. Technical Safety Appraisal is a documented, multidisciplinary appraisal of selected Department reactors and nuclear facilities conducted by a team selected by the Deputy Assistant Secretary for Safety, Health, and Quality Assurance (EH-30). They assure proper Department-wide application of particular safety elements of the ES&H program, nuclear industry lessons learned, and appropriate licensed facility requirements as described in DOE 5482.1B, paragraph 9b.
- r. Undue Risk is a level of identifiable risk which is unacceptable to DOE.
- s. Unreviewed Safety Question. A proposed change, test, or experiment shall be deemed to involve an unreviewed safety question if:
  - (1) The probability of occurrence or the consequences of an accident or malfunction of equipment important to safety evaluated previously by safety analyses will be significantly increased, or
  - (2) A possibility for an accident or malfunction of a different type than any evaluated previously by safety analyses will be created which could result in significant safety consequences.

- t. Verification of Training and Retraining is the confirmation by an auditable record of the experience, education, medical conditions, training, and testing pertinent to a candidate's specific job assignment and responsibilities. This record should satisfy all applicable requirements of paragraph 10.
6. APPLICATION. The requirements of this Order shall be applied to the siting, design, construction, maintenance, operation, modification, and decommissioning of a given facility with due consideration to the degree of risk that facility presents to employees, the public, and the environment. The responsibilities, authorities, and requirements outlined in this Order are to be applied in addition to those provided in DOE 5480.1B, and other Orders in the DOE 5480 series. Accelerator and nuclear reactor facilities and their operation are not included in this Order, but are covered by other Environmental, Safety, and Health (ES&H) Orders, as appropriate. This Order implements the Department's ES&H policy found in DOE 5480.1B.
7. RESPONSIBILITIES AND AUTHORITIES.
  - a. Under Secretary (S-3) has overall responsibility and authority for DOE programs and may take necessary management actions to ensure safety, including directing the curtailment and suspension of operations, when in his or her opinion, such operation would result in an undue risk.
  - b. Program Senior Officials (PSO), or their designees, perform the following functions for nuclear facilities under their program responsibility:
    - (1) Assume line management responsibility for nuclear facility safety.
    - (2) Review nuclear facility activities in their programs and field organizations to confirm that they are accomplished in consonance with the need for protecting the environment, safety, and health of DOE and DOE contractor employees, and the public.
    - (3) Approve the construction and initial operation of high hazard (as defined in DOE 5481.1B) nuclear facilities and subsequent modifications involving an unreviewed safety question after:
      - (a) Confirming that an acceptable safety analysis and an independent review have been made and documented.
      - (b) Determining that the safety analysis and independent review indicate that an adequate degree of protection of the environment, health, and safety exists.
      - (c) Obtaining the concurrence of the Assistant Secretary for Environment, Safety, and Health, EH-1 (see paragraph 7c(8)).

- (4) May approve the construction and initial operation of moderate hazard (as defined in DOE 5481.18) nuclear facilities and subsequent modifications involving an unreviewed safety question on a case-by-case basis depending on the nature of the hazard involved in accordance with subparagraph (3), above. A determination of the need for PSO approval will be made jointly, by the PSO and EH-1 prior to authorization of the Title I design after consultation with the field organization involved.
- (5) Transmit the results of the actions taken under subparagraphs (2), (3), and (4), above, to the responsible field organizations with any necessary or appropriate instructions as to subsequent action to be taken, with a copy to EH-1.
- (6) Submit to higher management for action, any disagreement with recommendations made during safety reviews that cannot be resolved. A copy shall be provided to EH-1.
- (7) Provide assistance to field organizations in the performance of safety reviews, appraisals, and the preparation of safety analysis reports.
- (8) Recommend additions or revisions to nuclear safety standards, guides, and codes to EH-1.
- (9) Confirm that field organizations comply with subparagraph 7e, below. In the execution of this responsibility, maximum use should be made of the appraisals and other reviews performed by EH, including assuring that recommendations made by EH are addressed in a responsive and timely manner.
- (10) Ensure the safe operation of nuclear facilities by:
  - (a) Directing the responsible field organization to require modification of equipment, procedures, or practices necessary for safe operation.
  - (b) Taking other actions to confirm the implementation of this Order, including directing the field organization to curtail or suspend the operation of nuclear facilities or related activities when necessary.
  - (c) Taking other actions as deemed appropriate.
- (11) Provide to the Assistant Secretary for Environment, Safety, and Health (EH-1) a copy of directions given under subparagraph (10), above.
- (12) Include, in long range program objectives and plans, the requirements to assure safe operation.

- (13) Ensure that program budgets provide adequate funds for health and safety requirements during all phases of facility life.
  - (14) Consider nuclear facility safety factors in connection with review and approval of designs, program and project proposals, and other proposals requiring Headquarters action.
  - (15) Obtain special technical assistance as needed in the performance of assigned functions when the expertise is not available in the office in need of assistance.
  - (16) Participate in selected field organization functional appraisals in accordance with DOE 5482.1B.
  - (17) Review and approve the field organization designation of nuclear facilities with the concurrence of EH-1.
  - (18) Assume the responsibilities assigned to Heads of Field Organizations in subparagraph 7e, below, for DOE program activities not assigned to a field organization.
  - (19) Actively monitor the decision-making process of the field organizations in determining candidate modifications/operations which can involve an unreviewed safety question.
  - (20) Transmit to cognizant field organizations proposed additional safety requirements beyond those required by this Order. Upon consideration of field organization assessments of such requirements and EH-1 comments, provide final approval.
  - (21) Transmit to EH-1 appropriate nuclear facility safety program and project direction documentation for concurrence (see paragraph 7c(13)).
- c. Assistant Secretary for Environment, Safety, and Health (EH-1) performs the following functions:
- (1) Provides the Secretary (S-1) with an independent safety overview and assessment of the operation of DOE-owned nuclear facilities.
  - (2) Establishes priorities for conducting appraisals of programs in conjunction with the Program Senior Officials and Heads of Field Organizations.
  - (3) Assures that nuclear facilities projects are consistent with DOE nuclear safety policy.
  - (4) Overviews and appraises nuclear safety activities of the cognizant Program Senior Officials and the field organizations to assure that DOE nuclear projects are accomplished in consonance with a need for protecting the safety and health

of DOE and DOE contractor employees and the public. Specific emphasis will be placed on training programs to assure that they include requirements necessary to achieve the goal of well-trained operators.

- (5) Develops and maintains Department-wide qualification and training standards for operators.
- (6) Assures that responsible EH personnel are proficient in the operations personnel training area, including diverse expertise so that important areas related to nuclear safety are covered.
- (7) Collects new safety requirements applicable to licensed nuclear facilities and consults with the cognizant PSO to make a preliminary evaluation to determine potential applicability to DOE nuclear facilities and:
  - (a) Evaluates field organization assessments and PSO disposition of newly proposed requirements and consider the requirements for inclusion in DOE Orders, as appropriate.
  - (b) Maintains a summary of the consideration and disposition given by DOE to each of the newly proposed requirements for nuclear facilities.

NOTE: The above process for implementing newly proposed requirements into DOE Orders does not relieve the line program organization from its responsibility to assure that new requirements are considered and applied as necessary to their facilities.

- (8) Reviews and concurs in the safety-related aspects of approvals granted under subparagraphs 7b(3) and 7b(4), above.
- (9) Actively monitors the decision-making process of the field organizations in determining candidate modifications/operations which can involve an unreviewed safety question.
- (10) Develops guidance and establishes requirements for nuclear facility safety policy.
- (11) Conducts technical safety appraisals of DOE high hazard and selected other nuclear facilities. Planning and conduct of these appraisals will be coordinated with appropriate field organizations and Headquarters program offices to minimize overlap or duplication of effort. Appropriate field organization and Headquarters program offices will be requested to participate.
- (12) Participates in selected field organization functional appraisals in accordance with DOE 5482.1B.

- (13) Reviews and concurs in nuclear facility safety program and project direction issued by the PSO to the field that affects more than one field organization.
- d. Deputy Assistant Secretary for Naval Reactors (NE-60),
- (1) Directs a program for assuring environmental protection, safety, and health protection at supporting contractor facilities for the Naval Reactors program and fulfills the responsibilities described for Heads of Field Organizations under subparagraph 7e, below, for the Schenectady and Pittsburgh Naval Reactors Offices.
  - (2) Fulfills the responsibilities of this Order and DOE 5482.1B, for criticality control and nuclear facility safety overview, assessments, and appraisals for nuclear facilities under the cognizance of the Deputy Assistant Secretary for Naval Reactors.
  - (3) Shall be exempt from the requirements to (a) submit copies of correspondence reports, and documents as provided elsewhere in this Order to EH-1, and (b) obtain EH-1 concurrence for initial operation or for changes to high or moderate hazard facilities for: 1 unreviewed safety questions; 2 changes to operations safety requirements; 3 changes to generic nuclear facility safety policy guidance; or 4 generic exemptions from environmental protection, safety, and health protection policies, standards, codes, guides, and procedures.
- e. Heads of Field Organizations shall, for nuclear facilities and operations under their jurisdiction:
- (1) Assume line management responsibility for the safety of assigned nuclear facilities.
  - (2) Assure adequate consideration for, and take action on, environmental protection, safety, and health protection matters during siting, design, construction, operation, maintenance, modification, and decommissioning.
  - (3) Require preparation of, and review, safety analyses including nuclear criticality safety evaluations and changes thereto consistent with this Order, DOE 5481.1B, and other Orders in the DOE 5480 series.
  - (4) Require preparation of, and approve, facility Operational Safety Requirements and changes thereto for nuclear facilities.

- (5) Authorize construction and initial operation of a new high/moderate hazard nuclear facility after assuring that adequate consideration has been given to all hazards including nuclear criticality safety; and determining by reviewing safety analyses and Operational Safety Requirements and the performance of an operational readiness review that its operation will not create undue environmental protection, safety, or health protection risks. For high hazard nuclear facilities and selected moderate hazard nuclear facilities (see paragraph 7b(4), above) cognizant PSO approval with EH-1 concurrence must be obtained prior to authorization.
- (6) Authorize activities, operations, and modifications that involve an unreviewed safety question only after assuring that:
  - (a) The contractor has performed and documented a safety review of each proposed change.
  - (b) An independent safety review has been performed by the field organization and documented to assure that continued operation is acceptable for environmental protection, safety, and health protection.
  - (c) An operational readiness review has been conducted and documented.
  - (d) Approval has been obtained from the cognizant PSO with EH-1 concurrence for high hazard nuclear facilities and selected moderate hazard nuclear facilities ( see paragraph 7 b(4), above) when an unreviewed safety question exists.
- (7) Take such action as may be appropriate, including curtailment and suspension of operations when, in their opinion, such operations may result in an undue risk to health, safety, or the environment.
- (8) Assist in the review and development of ES&H codes, standards, and guides.
- (9) Conduct periodic appraisals of each contractor's nuclear facilities in accordance with this Order, DOE 5482.1B, and other Orders in the DOE 5480 series.
- (10) Review additional safety requirements to determine their applicability to specific facilities, and submit assessments of such proposed requirements to the cognizant PSO and EH-1.
- (11) Identify those facilities on his or her site(s) which are designated to be nuclear facilities and submit the list to the cognizant PSO for approval.

- (12) Provide the PSO (with a copy to EH-1) appropriate safety documentation (e.g., safety analyses reports, operational safety requirements, criticality safety evaluations) to permit those organizations to meet their responsibilities as outlined in this Order, in particular, paragraphs 7b(3) and (4), and 7c(8).
  - (13) For high and moderate hazard nuclear facilities, determine whether a proposed modification involves an unreviewed safety question and forward pertinent documentation to the cognizant PSO (with a copy to EH-1) for review to support approval of the modification and subsequent operation. In those cases where there may be some uncertainty as to whether a modification involves an unreviewed safety question, actively involve the cognizant PSO and EH-1 in the determination.
  - (14) Assure that DOE contractors to whom this Order is made applicable implement the requirements in paragraphs 8 through 13 of this Order, and provide advisory services to DOE contractors and subcontractors on matters dealing with environmental protection, safety, and health protection policies, standards, codes, guides, and procedures, including the requirements of this Order.
  - (15) Provide for an overview of nuclear facility safety in their organization independent of line management responsibility.
8. **BASIC REQUIREMENTS.** The environment, safety, and health program for nuclear facilities shall include the following:
- a. A safety analysis and review process which includes a formal documented system for the identification and control of risks through preparation, independent review, and approval of safety analyses. The requirements of DOE 5481.1B shall be applied. In addition, new safety analysis reports prepared for nuclear facilities shall follow appropriate Nuclear Regulatory Commission Regulatory Guides on standard format and content of safety analysis reports.
  - b. Administrative and procedural controls that delineate (1) clear lines of responsibility and methods for safe operation under normal and emergency conditions, and (2) a system of configuration control that requires independent safety review and approval of all changes to components, equipment, procedures, and systems required for facility safety.
  - c. A documented training program for personnel involved in operating nuclear facilities which meets the requirements specified in paragraph 10.
  - d. Operational Safety Requirements setting forth the approved limitations of safe operation. The requirements shall be concise and commensurate with the potential risks involved.

- e. A quality assurance program in accordance with DOE 5700.6B.
  - f. Application of ES&H codes, standards, and guides covering siting, design, construction, modification, operation, maintenance, deactivation, decontamination, and decommissioning. Where established standards are determined to be inadequate or unavailable, suitable operating standards shall be developed, using contractor expertise as necessary, so that a defined and agreed upon basis for conducting and assessing operations is established and used. The safety analysis or other design documentation shall identify, on a facility-specific basis, the standards applied.
  - g. Notification, investigation, and reporting of occurrences and utilization of a followup system to assure remedial action has been implemented. (See DOE 5484.1 and DOE 5000.3.)
  - h. For new nuclear facilities and for significant modifications to existing nuclear facilities, review of safety analyses design criteria, environmental assessments and environmental impact statements, and other design documents to assure adequate ES&H consideration.
  - i. For new nuclear facilities and for significant modifications to existing nuclear facilities, reviews and inspections during construction, acceptance of systems, and preoperational phases to assure compliance with the appropriate ES&H standards and requirements.
  - j. A formal documented system for the control and traceability of records and documentation specified herein.
  - c. Emergency plans to handle potential accidents in accordance with DOE 5500.2, 5500.3, and DOE 5500.4 including appropriate medical response to radiation incidents.
  - l. A program of nuclear criticality safety which meets the requirements of paragraphs 11 and 12.
  - m. A contractor independent safety review and appraisal system which meets the requirements of paragraph 9.
  - n. The safe storage criteria for unirradiated/fissionable material meeting the requirements of paragraph 13.
9. CONTRACTOR INDEPENDENT REVIEW AND APPRAISAL SYSTEM. Each contractor to whom this Order is made applicable shall establish and maintain an internal safety review system for nuclear facilities which:

- a. Functions primarily in an advisory capacity to the line organization, reporting to a designated official at a level of management sufficiently high to take any necessary corrective action. (Safety is a line responsibility; neither review nor subsequent approval releases line management from its responsibility for the safety of people and equipment.)
- b. Is clearly defined and delineated in writing (e.g., purposes, objectives, functions, authority, responsibility, composition, quorum, meeting frequency, and reporting requirements).
- c. Can be audited by contractor management and by DOE. The performance of the system shall be recorded in sufficient detail to permit contractor management and DOE to evaluate its effectiveness. Actions taken on any recommendations resulting from reviews, audits, inspections, appraisals, and surveillance shall be included in these records.
- d. Provides technical competence in the areas being reviewed. Each review, except that described in subparagraph 9i, below, shall be carried out by persons whose technical disciplines cover the range of technical fields encountered in performing a safety review. Safety considerations are to be treated in the breadth and depth necessary to identify potential hazards and to evaluate the risks.
- e. Provides for group discussions between reviewers on all but the more routine matters.
- f. Provides an independent determination of whether a proposed activity involves an unreviewed safety question, violation of a Criticality Safety Limit, Operational Safety Requirement, or any matter for which approval is required.
- g. Provides an appraisal of the overall operation of each facility at least annually. The majority of the individuals performing the appraisal shall be independent of the operation being appraised. It shall include, but not be limited to, applicable areas listed in subparagraph 9h, below.
- h. Provides for objective and independent review of:
  - (1) Proposed modifications to nuclear facilities and equipment having safety significance, and safety analyses thereof.
  - (2) Proposed experiments and operations having safety significance.
  - (3) Administrative, operating (normal and abnormal), maintenance, repair, testing, quality assurance, and emergency procedures and significant changes thereto.

- (4) Organization and staffing.
  - (5) Standards, Nuclear Criticality Safety Limits, Operational Safety Requirements, and changes thereto.
  - (6) Nuclear facility safety training programs, including the initial and subsequent qualification and verification requirements and procedures for criticality safety.
  - (7) Unusual occurrences, including those referred to as incidents, operating anomalies, and violations of Nuclear Criticality Safety Limits or Operational Safety Requirements.
  - (8) The physical condition of the nuclear facilities.
  - (9) The accuracy and completeness of recordkeeping and documentation.
  - (10) Facility operations against its safety analyses.
  - (11) Facility operational compliance with the requirements of this Order.
- i. Is reviewed by contractor management for adequacy of performance at least every 3 years.
10. **PERSONNEL SELECTION AND TRAINING.** A program shall be established for the selection training, and retraining of all individuals who operate, maintain, or supervise activities in nuclear facilities. The program will promote an awareness of the risks involved and a level of proficiency consistent with assigned tasks. The purpose of this program is to assure that the nuclear facility is operated and maintained by personnel who are qualified to carry out their assigned responsibilities. It includes the following:
- a. **Operating Personnel.**
    - (1) The elements of the training program shall be documented.
    - (2) Achievement by the candidate of the necessary qualification status, both initially and on a continuous basis, to perform his or her assigned tasks in a safe and proficient manner shall be documented.
    - (3) Sufficient time shall be provided for training and retraining on a continuing basis.
    - (4) For each type of nuclear operation, management shall determine the physical demands imposed upon the operating personnel by the job tasks that are

required to perform both routine and emergency duties. A medical examination shall be given to prospective employees and a reexamination shall be given to requalifying operators and supervisors to verify health and physical fitness to safely perform their defined tasks. Operators and supervisors must be cleared by medical examination prior to returning to work following any serious injury or illness.

- (5) On-the-job training shall be provided to assure that personnel are familiar with all aspects of their positions. Such training shall include but not be limited to:
  - (a) Normal procedures;
  - (b) Emergency actions;
  - (c) Radiation control practices;
  - (d) Location and functions of the pertinent safety systems;
  - (e) Configuration control procedures;
  - (f) Procedures for making changes or alterations in the operations; and
  - (g) Operational Safety Requirements.
- (6) Verification of training shall be made by a cognizant management or supervisory official following a finding that the candidate's proficiency is satisfactory after completion of the training program and receipt of a satisfactory statement of the candidate's medical condition and other pertinent information. Verification of training for fissionable material handlers, operators, or supervisors may not be made by his or her immediate supervisor.
- (7) Retraining and reexamination shall be required at least annually on all procedures for handling abnormal nuclear facility conditions and emergency situations relative to the employee's assigned responsibilities, and at least every 2 years on all other subjects in which the fissionable materials handler, operator, or supervisor is expected to be proficient.
- (8) Verification of training shall be documented by contractor management at least every 2 years.
- (9) The program shall be auditable by contractor management and by DOE.

- (10) In addition to the above, a program shall be established for those fissionable materials handlers, operators, and supervisor candidates who process, store, transfer, or handle significant quantities of fissionable material, which includes the following elements:
- (a) Fissionable materials handlers, operators, and supervisor candidates shall possess formal training, pertinent experience, or both, commensurate with the stated, degree of responsibility and complexity of the prospective position.
  - (b) The training program shall provide for evaluating the progress of each trainee periodically during training. Each evaluation shall require the demonstration of a satisfactory knowledge of all required subjects and procedures covered in the training program. This demonstration may include written, oral, and operational examinations as appropriate to the position, experience, and educational level of the employee. Upon completion of the program, the final evaluation of the candidate's proficiency shall be made by the examining official. A file record of the employee's training, including a record of the subjects covered in oral and operating tests along with the written examinations, shall be maintained.
  - (c) Retraining for fissionable materials handlers, operators, and supervisors following extended absence from the nuclear facility shall be required. The extent of retraining will depend upon the length of absence and the type of work and operational routine in the events of changes. For absences of 3 months or less, if retraining is deemed necessary, informal retraining and oral testing may be sufficient. For absences of 3 to 12 months, selected retraining as appears necessary, including training in the use of, and familiarization with, any new devices or changes in the process, with appropriate demonstrations of knowledge and proficiency, is required. For absences greater than 1 year, a written reexamination shall be required and where indicated by the results of that examination, retraining shall be mandatory.
  - (d) The program shall provide for training, retraining, examination, and reexamination in the following areas to the extent that they are pertinent to the position in question (e.g., supervisor training shall require an understanding in greater depth than fissionable materials handler and operator training):

- 1 Standard and Emergency Operating Procedures. Normal operating procedures, abnormal and emergency actions, and administrative controls and responsibilities
  - 2 Radiological Safety and Control. Radiation hazards, monitoring, safety practices, control procedures, and terminology.
  - 3 Safety and Emergency Systems. The kind of equipment, operating characteristics and procedures, and testing requirements of safety systems.
  - 4 Instrumentation and Control. Types of instruments and control systems, including principles of operation and consequences of malfunctions.
  - 5 Facility Operating Characteristics. Principal features, operating parameters, and operating limits of the facility, including the auxiliary systems.
  - 6 Principles of Nuclear Facility Operation. The processes involved and technical terminology for the chemical, physical, and metallurgical reactions.
- (e) In the case of initial startup of a new nuclear facility or operation precluding prior on the job training, practical experience at similar facilities, training on simulators, training with inert materials, or other appropriate training shall be considered.
- (f) The supervisor training program, in addition to the above, shall include the following material to the extent that it is pertinent:
- 1 Design control, and operating limitations for the facility, including instrumentation characteristics, adjustment, operation, facility console control mechanisms, and control room manipulations.
  - 2 Procedures for making design and operating changes, including changes in operating procedures.
  - 3 Radiation hazards which may arise during the performance of experiments other than those in critical assemblies.
  - 4 Nuclear and radiation theory, including details of fission process, neutron multiplication, source effects, neutron poison effects, and reactor kinetics.



- b. Identification of the Parameters on which Prevention of Accidental Nuclear Criticality will Depend. The basis for establishing subcriticality shall be noted for all significant conditions at each step in the process. In the case of established facilities or operations, this may consist of references to existing nuclear criticality safety evaluations.
- c. Written Plans and Procedures. Operations shall be governed by written plans and procedures. These plans and procedures shall be an integral part of the initial proposal for the nuclear facility, its operations, and subsequent modifications that may affect the nuclear reactivity. The plans and procedures shall include the following, where applicable:
  - (1) Plans for receiving fissionable material into the facility and for inspecting the shipment on receipt, including procedures for:
    - (a) Determining, verifying, or noting the contents of each package, including the net weight of fissionable material therein;
    - (b) Placing materials in the receiving area and the storage facility; and
    - (c) Handling wet or damaged packages.
  - (2) Plans and procedures for storing fissionable material, including:
    - (a) Limitations on total quantity of material, quantity of each individual unit, container dimensions, and spacing between units.
    - (b) Description of containers in which fissionable materials are stored.
    - (c) Description of the storage facility, including dimension and materials used in construction of the enclosure and shelving, cubicles, cages, and other equipment within the storage area.
    - (d) Precautions to avoid entry of water or other material into a storage area where moderating and reflecting effects would be unsafe.

- (e) Administrative controls over the distribution of fissionable material from storage and its return to storage, including means of verifying the weight, isotopic content chemical composition, and degree of moderation.
- (3) Plans and procedures for processing the fissionable material, including:
- (a) A description, using appropriate sketches or drawings, of equipment and facilities in which the hazard of criticality exists, and showing dimensions in sufficient detail to permit evaluation of the information mentioned in subparagraphs 11c(3)(c) and (f), below.
  - (b) A statement of the chemical and physical form of fissionable material in each step of the operation, including isotopic content, the nature of any material, and the resulting concentrations, densities, and degrees of moderation throughout the steps of the process.
  - (c) A statement of the maximum quantities of fissionable material allowed at any one time in each step of the process.
  - (d) Spacing of masses of fissionable material within each process area, and separation from fissionable material in adjoining areas.
  - (e) Methods of collecting, handling, and transporting fissionable material from each process area or individual operation, and evaluation of the nuclear safety of these methods.
  - (f) Description of procedures which are intended to prevent criticality resulting from accumulation of fissionable material in scrap or waste, lathe turnings, crucible slag, pickling solutions, choppings, sumps, or filters.
  - (g) Installed, or proposed criticality alarm system and emergency procedures, including alarm levels, fail safe features, response time of devices, and frequency of evacuation drills. Pertinent documents shall show the location of all detectors, their distance to possible sources of criticality, and intervening shielding. The criticality alarm system shall be installed in all locations wherein the quantities of fissionable material may exceed 700 grams of uranium-235, 520 grams of uranium-233, 450 grams of plutonium, or 450 grams of any combination of these three nuclides. Limits for other fissionable materials are as indicated in ANSI/ANS 8.15 1981, "American National Standard for Nuclear Criticality Control of Special Actinide Elements." These limits may be exceeded when justified by consideration of the physical form and isotopic distribution of the fissionable

material. This justification must be based upon a documented analysis demonstrating that, in such cases, the alarm system is not required. Special attention shall be given to all processes in which reflectors and moderators more effective than hydrogen are present and, as appropriate, the above limits reduced so that nuclear reactivity is not increased.

- (h) A monitoring system, using gamma- or neutron-sensitive radiation detectors which will initiate a clearly audible alarm, distinctive in tone, if accidental criticality occurs, is required. The detectors shall be capable of detecting a criticality condition that produces an absorbed dose in free air of 20 rads of combined neutron and gamma radiation at an unshielded distance of 2 meters from the fissionable material within 60 seconds. Provisions shall be made to minimize false alarms. These provisions may include concurrent response of two or more detectors or single, highly reliable detectors to initiate an alarm. In redundant systems, failure of any single channel shall be into the trip state. Warning of malfunctions within the alarm system without activation of the alarm shall be provided. Evacuation for such warning may not be required. This paragraph is not intended to require underwater monitoring when special nuclear material is handled or stored beneath water shielding that is adequate to protect personnel. Also, such alarm systems are not required for material during shipment or material packaged in approved shipping containers awaiting transport, provided no other operation involving fissionable material not so packaged is permitted on the dock or in the shipment area. Such an area or dock shall be located so that the interaction between fissionable material positioned thereon, and any other arrays of fissionable material is essentially zero. (See DOE 5480.3 for details regarding the safe shipment of fissionable materials.)
- (i) Where the function of the facility is to store radioactive waste packaged elsewhere, the plans and procedures required in subparagraph 11c(3), may be appropriately combined with those required for storage in subparagraph 11c(2).
- (j) The plans described in subparagraphs 12c(1) and (2) may make suitable allowance for situations where fissionable contents are repetitive or known from the work of others (e.g., the cases of mass-produced fuel elements and waste containers for which the fissionable content has previously been determined by a method known to be reliable).

- d. Records. Operations shall provide for control, signoff, and traceability of records, such as plans, procedures, inspections, and monitoring systems, regarding the collection, handling transportation, inspection, receipt, and monitoring of fissionable material.

12. NUCLEAR CRITICALITY SAFETY CONTROL PARAMETERS. Nuclear criticality safety of fissionable materials may be provided by maintaining any one of the single parameter limits set forth in the latest revision of ANSI/ANS-8.1-1983. Although the single parameter limits are adequate for many purposes they are inconveniently and uneconomically small for many others. In many cases, simultaneous limitation of two or more parameters may allow more flexible operational control. General guidance for multiparameter limits may be found in subparagraphs 4d, 14d, 14f, and paragraph 8 of this Order. The following basic control parameters for nuclear criticality safety shall be considered:

- a. Controlling Factors. Nuclear criticality safety is achieved by exercising control over:

- (1) The Mass and Distribution of All Fissionable Materials.

- (a) Mass Controls. For operations where nuclear criticality safety depends upon mass control, the allowable mass shall be no greater than the safe mass for the associated conditions. The safe mass in all cases shall be based upon current published or available nuclear safety guides and handbooks. These guides and handbooks may include values which, in the absence of directly applicable experimental measurements, are derived from calculations made by a method shown to be valid by comparison with experimental data, provided allowances are made for uncertainties in the data and in the calculations. For operations depending upon mass control where the contained volume does not automatically limit the contents to the safe mass or less, the possibility of multiple batching shall be considered. If a batch of fissionable materials consists of different physical and chemical forms of a particular isotope (e.g., metallic uranium-235, compounds of uranium-235), the safe mass for the most reactive combinations under the associated conditions shall be the governing criterion. If a batch of fissionable materials consists of a mixture of fissionable nuclides (e.g., plutonium-239, uranium-235, uranium-233, neptunium-237, and curium-244), the allowable safe mass shall be determined experimentally or determined from calculations made by a method shown to be valid by comparison with experimental data.
- (b) Density Controls. Density (mass of fissionable nuclides per unit volume) is an accepted parameter for control of nuclear criticality safety. Systems that use density control shall meet established density criteria. These criteria may be found in safety guides, handbooks, and data compilations.

- (c) Spacing Controls. Individual items of equipment and containers holding fissionable materials, when arranged in a group, in storage, or when being transferred within a nuclear facility or between facilities onsite, shall be spaced so that the entire array is subcritical for all conditions that affect or might affect the nuclear facility or site. Movement of material under credible in-plant and onsite accident conditions shall be considered.
- (2) The Mass, Distribution, and Use of the Nuclear Properties of All Other Materials With Which Fissionable Elements are Associated.
- (a) Neutron Absorbers. Neutron absorbing materials, such as cadmium and boron, may be used to make equipment and processes safe, provided available data confirm their suitability and assure their presence and reliability. Care should be exercised in the use of solutions of neutron absorbers because of the controls required to assure their continued effectiveness.
  - (b) Moderation Controls. For operations in which nuclear criticality safety depends upon control of neutron moderation, there shall be assurance that the prescribed extent of moderation remains unchanged or that, if it does change, the reactivity of the system remains below acceptable subcritical limits. Such assurance shall include consideration of all credible accidents involving any moderator or combination of moderators.
  - (c) Neutron Reflection. Neutron reflection shall be considered for all systems of fissionable material. The extent of reflection shall be based upon the actual reflectors present or those to be expected during normal operations or as a result of a credible accident.
- b. Double Contingency Principle. Process designs shall incorporate sufficient safety factors so that at least two unlikely, independent, and concurrent changes in process conditions must occur before an accidental nuclear criticality is possible.
- c. Geometry Control. Where practicable, reliance shall be placed on equipment design in which dimensions are limited, rather than on administrative controls. Full advantage may be taken of any nuclear characteristics of the process materials. Control shall be exercised to maintain all dimensions and nuclear properties on which reliance is placed.

- d. Nuclear Criticality Safety Limits. Limits for nuclear criticality safety shall be established on bases derived from experiments. In the absence of directly applicable experimental measurements, the limits may be derived from calculations made by a method shown to be valid by comparison with experimental data, provided allowances are made for uncertainties in the data and in the calculations.
  - e. Margins of Safety. Safety margins used shall meet the control parameter requirements above. Further, a cumulative margin of safety shall provide allowance for experimental and computational uncertainties. Procedure violations also shall be a consideration.
  - f. Onsite Movement and Offsite Shipment of Fissionable Materials.
    - (1) Onsite movement includes all activities where fissionable materials are transferred from one operation to another within a facility and from location to location onsite. For all such movements, the following requirements shall be met:
      - (a) For the onsite movement of fissionable materials that do not present a radiation hazard, the pertinent requirements set forth in this Order shall be met.
      - (b) For onsite movement of fissionable materials that presents radiation hazard, as well as the possibility of an accidental chain reaction, the pertinent requirements of this Order, DOE 5480.3, and DOE 5480.1A, Chapter XI.
      - (c) In addition to the physical controls specified above, administrative controls, including traffic controls, shall be exercised as deemed necessary by Heads of Field Organizations to minimize accident probabilities.
      - (d) Fire protection, security, health physics, and any other emergency personnel, when deemed appropriate by Heads of Field Organizations, shall be alerted and advised of movements and routings.
    - (2) Safety standards for the packaging of fissionable materials for any offsite shipment are outlined in DOE 5480.3. Further, such shipments shall meet the nuclear criticality safety requirements set forth in this Order and the radiological safety standards outlined in DOE 5480.1A, Chapter XI.
13. SAFE STORAGE CRITERIA FOR UNIRRADIATED FISSIONABLE MATERIAL. The criteria in subparagraphs 13b through d are applicable to the storage of all forms and significant quantities of unirradiated fissionable material.
- a. Exceptions. These criteria are not applicable:

- (1) When materials are in-process as part of production, analytical and developmental procedures, or transport operations.
- (2) When an assembly cell is used for assembly and/or storage of weapons components made with these materials.
- (3) When the number of packages of materials prepared for shipment is limited in accordance with the requirements of DOE 5480.3.
- (4) To radioactive waste storage or disposal facilities.

b. Operating Requirements for Storage.

- (1) Nonessential combustible materials shall not be stored in the storage area.
- (2) Process operations, storage of nonnuclear materials or equipment which is not directly required for storage operations, and all other functions not directly a part of normal storage operations shall be excluded from the storage area. Deviations from this requirement must be approved by the Head of the Field Organization.
- (3) Documented periodic inspections, in site tests, and, preventive maintenance shall be performed at designated frequencies to assure that the safety systems and components necessary for criticality control, fire control, radiation detection, and environmental monitoring, as well as their alarm systems, are being properly maintained in readiness for use.
- (4) Limits for criticality safety shall be posted in conspicuous places near the storage area.
- (5) Signs or other appropriate devices shall be utilized at strategic locations to provide instructions regarding:
  - (a) Interpretations of, and responses to alarms;
  - (b) Evacuation routes; and
  - (c) Combatting fires.
- (6) In conjunction with site emergency planning, a fire fighting plan shall be developed, incorporated into the overall site fire plan, and exercised through periodic drills which include use of emergency equipment.

- (7) Auxiliary fire fighting equipment, self contained breathing apparatus, and protective clothing shall be provided, as necessary, to facilitate manual fire suppression.
- (8) Excess fissionable material shall not be construed to be "In Process" to circumvent the requirements of this paragraph.
- (9) Fissionable material may be stored in shipping containers for the purpose of enhancing safety in storage, but not for the purpose of negating the requirements of this paragraph.
- (10) All material shall be stored in racks or equivalent equipment (such as birdcages) capable of securely locating stored material to prevent displacement, to assure spacing control, and to meet designs for safety under operational and credible accident conditions. Floor storage within the storage facility will be permitted only where control of location and other safety requirements (equivalent to those of racks) are inherently provided by the individual containers and their restraints.
- (11) All pyrophoric materials shall be put in a safe form prior to storage or stored in approved containers that will not permit spontaneous ignition or dispersal. Other dispersible materials must be stored in approved storage containers.
- (12) All containers shall be marked or coded to indicate the type or category of material, amount, degree of enrichment, and the radiation level at the outside surface of the vessel. Containers shall be securely closed and positioned so as to prevent significant displacement and maintain criticality prevention requirements.
- (13) Container design shall be appropriate to the form of stored material. Criteria for container integrity shall be developed in the course of the required safety analysis and the application of these criteria ascertained by periodic inspection. Containers involving any significant gas buildup, automatic pressure relief, or other venting should be designed to assure that no personnel exposure to any released toxic material will occur under normal storage conditions or, insofar as practical, under accident conditions. Such venting must not permit spread of contamination.
- (14) Plutonium or U-233 bearing or contaminated material shall be packaged in a closed metal container. Combustibles within the container shall be minimized.
- (15) Plutonium storage facilities and containers shall be monitored and checked periodically to assure continued integrity of containment. When required by the form or hazard potential of the stored material, procedures shall be developed to detect contamination or loss of primary containment upon entering the plutonium storage facility.

- (16) Plutonium containers in which gas buildup can occur shall be designed to prevent leakage of gas over the maximum storage period or vented to prevent an accumulation of explosive gases; however, such venting must not permit spread of contamination.
  - (17) Criteria, such as external and internal corrosion rate for determining suitability of the plutonium containers, shall be developed and set forth in writing. All containers shall be periodically inspected against the criteria developed. The time between inspections may vary depending upon container quality and type.
  - (18) Provisions shall be made in a plutonium storage facility assure necessary and adequate heat removal for plutonium containers as established by the safety assessment.
- c. Multipurpose Facility (Storage and Processing) Criteria. In making the safety assessment for any building or area which includes both storage and processing functions, the operating contractor shall, with the approval of the Head of the Field Organization, specify which manufacturing, production, or laboratory materials may be termed "in-process" and which may not. Materials in excess of in-process requirements shall be promptly placed in approved storage facilities. Definitions of in-process material shall be established and approved prior to the start of the related operations and maintained thereafter unless approved changes are effected.
  - d. Facility Functional Design Requirements for Storage. The design criteria shall meet the requirements of DOE 6430.1, GENERAL DESIGN CRITERIA, Chapter XXI, "Plutonium Facilities," and Chapter XXIII, "Unirradiated Enriched Uranium Storage Facilities."
14. SAFETY GUIDES. The following documents may be useful in nuclear facility safety work:
- a. ANSI N16 Series, N16.1 through N16.5 inclusive, N16.8, and N16.9.
  - b. "Handbook of Nuclear Safety" (DP 532), 1-61, H. K. Clark.
  - c. "Critical Dimensions of Systems Containing U-235, Pu-239, and U-233" (TID-7028)
  - d. "Criticality Problems of Actinide Elements," Actinides Reviews 1 (1971): 409-432, E. D. Clayton and S. R. Bierman.
  - e. "Criticality Control in Chemical and Metallurgical Plants," Karlsruhe Symposium, Organization for Economic Cooperation and Development, European Nuclear Energy Agency, 1961.
  - f. "Criticality Control of Fissile Materials," Proceedings of Symposium, Stockholm, Sweden, International Atomic Energy Agency, 1966.

- g. The Criticality Data Center Report Series.
- h. "Nuclear Safety Guide" (TID 7016, Revision 2, 1978, available as NUREG/CR-0095).
- i. "Criticality Control in Operations with Fissile Materials" (LA-3366, Rev.), 11-72, H. C. Paxton.
- j. "Los Alamos Critical Mass Data" (LAMS 3067), 5-64, H. C. Paxton.
- k. "Nonreactor Nuclear Facilities: Standards and Criteria Guide," DOE/TIC-11603, of October 1981.
- l. "A Guide to Radiological Accident Considerations for Siting and Design of DOE Nonreactor Nuclear Facilities," LA-10294-MS, of January 1986.



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Secretary